Digging Wikipedia: The Online Encyclopedia as a Digital Cultural Heritage Gateway and Site

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The online encyclopedia Wikipedia is both a cultural reference to store, refer to, and organize digitized and digital information, as well as a key contemporary digital heritage endeavor in itself. Capitalizing on this dual nature of the project, this article introduces Wikipedia as a digital gateway to and site of an active engagement with cultural heritage. We have developed the open source and freely available analysis architecture Contropedia to examine already existing volunteer user-generated participation around cultural heritage and to promote further engagement with it. Conceptually, we employ the notion of memory work, as it helps to treat Wikipedia's articles, edit histories, and discussion pages as a rich resource to study how cultural heritage is received and (re)worked in and across languages and cultures. Contropedia's architecture allows for the study of the negotiations around and appreciation of cultural heritage without assuming an unchallenged and universal understanding of cultural heritage. The analysis facilitated by Contropedia thus sheds light on the contentious articulation of perspectives on tangible and intangible heritage grounded by conflicting conceptions of events, ideas, places, or persons. Technologically, Contropedia combines techniques based on mining article edit histories and analyzing discussion patterns in talk pages to identify and visualize heritage-related disputes within an article, and to compare these across language versions. In terms of digital heritage, Contropedia presents a powerful tool that opens up a core resource to cultural heritage studies. Moreover, it can form part of a conceptually grounded, technically advanced, and practically enrolled infrastructure for public education that opens up the dynamic formation of both knowledge about cultural heritage and new forms of digital cultural heritage that show a considerable amount of friction.

CCS Concepts: ● **Information systems → Digital libraries and archives**; ● **Human-centered computing → Wikis**; *Empirical studies in collaborative and social computing*; Collaborative content creation; ● **Applied computing → Arts and humanities**

Additional Key Words and Phrases: Memory work, controversy metrics, cross-cultural studies, Contropedia

1. INTRODUCTION

The global cultural heritage movement arguably follows two cardinal ambitions: on the one hand, to preserve the physical property as well as the nonphysical aspects of cultures, an aim pursued by many local, national, and transnational activities [Gillman 2010]. On the other, there are tendencies to treat these items and ideas as "resources." The appraisal of cultural heritage consequently involves a range of initiatives that seek to interact with the legacies of artifacts as well as systems of value and meaning [Appadurai 1986; King 2013; Lowenthal 1985]. Rather than taking cultural heritage as merely consisting of storable entities, it comes to play a crucial role in relation to past and contemporary civilizations that encompass all sorts of tangible and intangible creations. Hence, besides questions of conservation and ownership, we find numerous political, legal, pedagogical, and technological projects to make cultural heritage accessible and to draw people into an active engagement with the objects and thoughts that constitute cultures [Smith 2006].

From this background, the focus of this article is on the online encyclopedia Wikipedia. In terms of cultural heritage, encyclopedias are material and intellectual manifestations of cultural patrimony in their own right [Darnton 1987]. As such, these publications are veritable achievements perpetuating a society's abundance and orientation. Furthermore, they are pivotal access points to cultural heritage, as they open up and order a realm of knowledge about objects and concepts worth retaining [Burke 2012]. In this regard, Wikipedia can be seen as both a cultural reference to store, refer to, and organize digitized and digital information as well as a key contemporary digital heritage endeavor in itself.

The engagement with cultural heritage on Wikipedia takes places in various forms and at different venues across the project. Apart from different language versions of articles, which often also demarcate cultural fault lines, diverse and commonly divergent positions are brought forth within single articles, too. For instance, entries about material manifestations of cultural heritage such as the Elgin Marbles, Al-Aqsa Mosque, Priam's Treasure, or Bamiyan Buddhas have, not surprisingly, been permeated with cognate discussions about their significance, custody, and protection. Likewise, entries on intangible events, concepts, or ideas such as the different language versions of marriage, *Zwarte Piet* (Black Pete), or bullfighting give way to contested perspectives on traditions, customs, or beliefs. However, also less obviously culturally sensitive entries such as those about local food like feta, Shopska salad, or hummus showcase disputed narratives around origin and cultural authority.[1] Consequently, in this article, we argue that the analysis of Wikipedia articles, their edit histories, and discussions (on so-called talk pages accompanying, by default, all articles) as well as the interlingual comparison of articles may lay bare conflictual contemporary stances and historical references around cultural heritage.

In this article, we thus introduce Wikipedia as a digital gateway to and site of the active engagement with cultural heritage. Although there are several significant innovations for heritage-oriented computer-based applications within professional archaeological or museum contexts [Giaccardi 2012; Katz et al. 2011], we propose the open source and freely available analysis architecture Contropedia

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[1]Some of these examples are further elaborated in this article. The other examples can be found at http://contropedia.net/demo/index.php?

to examine already existing volunteer user-generated participation around cultural heritage and to promote further engagement with it [Borra et al. 2015]. In terms of digital heritage technology, Contropedia presents a powerful tool that opens up a core resource to cultural heritage studies and thus contributes to ongoing efforts in supporting and managing the use of facilities and applications in the digital heritage sector. In line with digital methods' proposition to repurpose data and functionalities within already existing digital resources and platforms [Rogers 2013a; Weltevrede 2016], Contropedia allows for studying the negotiations around and appreciation of cultural heritage. In light of the common archaeological practice of excavating buried sites, but also in reference to data mining approaches, we might therefore speak, somewhat metaphorically, of "digging Wikipedia."

Instead of assuming an unchallenged and universal understanding of cultural heritage, the investigation made possible through such an approach sheds light on the contentious articulation of perspectives on tangible and intangible heritage grounded by conflicting conceptions of events, ideas, places, or persons across linguistic boundaries [Ashworth et al. 2007; Harrison 2009; Sandis 2014].

2.   UNDERSTANDING WIKIPEDIA AS A DIGITAL GATEWAY TO AND SITE OF CULTURAL HERITAGE

Thinking of Wikipedia as an encyclopedia and a collaborative project that involves editors in more than 250 languages to contribute to "the sum of all human knowledge" [Miller 2004], we zoom in on the knowledge production manifested in the edit histories and talk pages of Wikipedia articles to gain insights into the ways stances about particular cultural heritage resources are negotiated and presented. The history page logs each edit and its author, and the talk page is the parallel space for discussion about the contents of an article. We depart from the insight that Wikipedia's articles, edit histories, and talk pages offer a rich resource to study how cultural heritage is received and (re)worked in and across different cultures and languages by employing the notion of memory work.

2.1   Conceptualizing Memory Work Around Cultural Heritage

Through active engagement with cultural heritage artifacts, people learn about their physical properties and semantic dimensions. Establishing a connection to preserved objects and attributes, people can also come in touch with wider historical contexts of cultural institutions and forms of organization in which artifacts once had their place and certain ideas were widely taken for granted. Moreover, this active engagement and participation is not only a backward-looking enterprise but invites one to recognize how contemporary societies share and pass on memories around their tangible and intangible cultural heritage.

Acknowledging this "productive remembering" [Huyssen 2003, p. 27] of cultural heritage in light of present concerns can capitalize on concepts of cultural memory and memory work in particular [Benton 2010; Samuel 2012]. Since the very beginnings of human civilization, collective memories have been constituted and passed down through cultural heritage as they form part of social acts of commemoration. Over the past two decades, the theoretical and empirical interest in the construction, transfer, and contestation of memories has become a key area of research not only in the newly established field of memory studies but also in humanities and social sciences at large using different yet related concepts of collective, cultural, or national memory (e.g., see Erll Nünning and Young [2008] and Olick and Robbins [1998]). There, memory is commonly defined as "the present past" [Terdiman 1993, p. 8], which echoes the classical insights of Halbwachs [1992] into the constitution of the past in terms of present worldviews and concerns. Hence, studying the active engagement with cultural heritage through the lens of memory assumes that people communicate and challenge their understandings of and engagement with historical objects, persons, and events. Through their memory-related practices, they build up and retain a sense of collectivity and relate to different collectives by imagining others as a commemorative community or nation by sharing memories with others or by constructing the

Fig. 1.   Screen capture of Wikipedia Template:Globalize. Source: https://en.wikipedia.org/wiki/Template:Globalize.

idea of continuity or difference between themselves and other people [Assmann 2011; Connerton 1989; Lohmeier and Pentzold 2014].

To take these insights further, the notion of memory work dealing with cultural heritage can be employed. For van Dijck [2007, p. 5], memory work "involves a complex set of recursive activities that shape our inner worlds, reconciling past and present, allowing us to make sense of the world around us, and constructing an idea of continuity between self and others." Furthermore, Kuhn [2010, p. 303] explains that "memory work is an active practice of remembering that takes an inquiring attitude towards the past and the activity of its (re-)construction through memory." Building on the concept's sensibility for the effort that goes into commemorating, we argue that it could be used, on the one hand, to cover heritage-related practices and, on the other, to recognize the extent to which such work is done in, with, and through computer-based platforms and tools. The notion of memory work thus refers to practices for engaging with tangible and intangible cultural heritage by way of representation, interpretation, reflection, and negotiation. In this work, Wikipedia articles and their edit histories and talk pages are positioned as venues where such memory work concerning digital heritage can and should be studied.

2.2   Specifying Memory Work in Wikipedia

Overall, the online encyclopedia Wikipedia plays a central role for virtually any kind of inquiry in Western societies and increasingly worldwide. It is the world's sixth most visited Web site, receiving hundreds of millions of hits monthly [Zachte 2016]. Wikipedia is also a core reference for different knowledge-intensive sectors like schools, universities, consulting, businesses in the service and information sector, and journalism [Messner and South 2011; Thelwall and Stuart 2007]. The prominent position of Wikipedia as a reference work has, however, raised concern about its reliability and balance. Tests have compared Wikipedia to other reference works and obtained mixed results [Giles 2005; Stvilia et al. 2008; Wikipedia 2014]. Yet such an approach ignores that Wikipedia is not a traditional encyclopedia, as its articles can be edited (almost) anytime by (almost) anyone. As such, the value of Wikipedia content is guaranteed less by absence of errors than by their constant "improvability." In an analogous way, Wikipedia's core principle "neutral point of view" (NPOV) is assured by the possibility of editors with different viewpoints to correct each other and write it in such a way that all significant viewpoints are represented with due weight [Wikipedia Contributors 2015c]. The quality of Wikipedia, in other words, is made possible by the struggle over its content.

On the face of it, approaching Wikipedia as a site to study various perspectives related to cultural heritage appears counterintuitive, or even a category mistake, as Wikipedia is meant to be an online equivalent and extension of an encyclopedia, with particular principles and standards that would prevent articles from being particularistic or parochial. Wikipedia articles are not only meant to follow core principles that would remove any perspectives or points of view that are not construed as neutral. The articles also are thought to be universal, or "global," in their outlook. For example, the instructive "globalize" template points to the idea that Wikipedia articles should attain a global view and would err in case they do not (Figure 1).

In other words, it seems that articles should be drained of cultural perspective and arguably over time would have any perspective contained therein smoothed over (when the template could be removed). The goal for the contributors is to reach consensus, where "decision-making involves an effort to incorporate all editors' legitimate concerns" [Wikipedia Contributors 2015d]. In addition to adhering to the core principle NPOV, they should, moreover, present knowledge that is verifiable, with references made in the articles to reliable sources, often with outlinks to sources external to Wikipedia [Wikipedia Contributors 2015b]. Wikipedia's third core principle is that the articles are supposed to contain no original research [Wikipedia Contributors 2015a]. Overall, the improvement by discussion is visible in the history page and talk page of each article, constituting the very core of the collaborative encyclopedia. By studying the process through which an entry comes into being, through inspection of the revision history and talk pages, one can study the process by which an entry matures.

The concept of memory work helps to think through Wikipedia's status as a digital gateway to and site of the active engagement with cultural heritage. In Wikipedia, the production of articles and the discussions on the associated talk pages can be viewed as the dynamic constitution of cultural memory, where forms of objectified culture (e.g., texts and images) are crystallized. Hence, given Wikipedia's cultural significance, it can be argued that the creation of encyclopedic articles and the network of articles on historical objects, ideas, events, or persons present important sites where volunteer editors contribute and discuss personal understandings, historical insights, and scientific references to construct knowledge around cultural heritage. The disputes on the talk pages and their transition to the encyclopedic article texts are exposed under laboratory-like conditions [Latour and Woolgar 1979]. The "permanent conflictuality" [O'Neil 2009, p. 176] displayed in the article production and in the discussions on Wikipedia thus indicates a significant and information-rich heritage-related memory work.

Analyzing controversies among volunteer editors means examining Wikipedia as a digital site to store materials about tangible and intangible cultural heritage and as a digital gateway to engage in memory work. In this regard, usually locally disconnected people with different ethnic, national, ideological, or religious backgrounds can express and debate their understandings of cultural heritage and constitute knowledge around cultural heritage in and across cultural and linguistic boundaries [Pentzold 2009]. The editors do not operate as a closely knit group but as a loosely organized collective whose interactions can be described, Wertsch [2002] proposed, as "contested distribution" (p. 24).

The extensive availability of edit logs and discussions on talk pages, together with Wikipedia's prominence, make it an ideal site to observe the memory-wise constitution of knowledge that is key to understanding the accounts of and engagement with cultural heritage between consensus and contestation. Although the built-in edit history and talk pages of a Wikipedia article provide a detailed record of present and past changes to the content of articles and the unfolding of discussions, these pages are usually ignored by the general public, as they are deemed too complex to be understood by casual readers and too massive to be widely and systematically analyzed quantitatively. Furthermore, it often remains unclear what issue has actually provoked a certain discussion and how this then translated into the constitution of the encyclopedic entry. We have developed Contropedia to address these limitations and to provide insight into the memory work that went into Wikipedia articles [Borra et al. 2015].

Contropedia's computational architecture allows for studying Wikipedia as a cultural reference and as a site of memory work concerning tangible and intangible heritage. More precisely, current versions of articles can be compared across languages so as to provide insight into different points of view per language (see also Bao et al. [2012] and Massa and Scrinzi [2013]). In addition, edit histories and talk pages can be exploited to study memory work within a particular language version and can, using Contropedia's ranking and controversy algorithm, be deployed to examine which issues have been disputed most within a particular language and across languages.

3. USING CONTROPEDIA TO ANALYZE NEGOTIATIONS ON CULTURAL HERITAGE REPRESENTATIONS

The relevance of Wikipedia as a reference work for collaborative knowledge production, together with the complete availability of editor activity logs, has made it a preferential subject of research in various fields of study. When looking at the list of research projects performed with or on Wikipedia, a clear distinction between the use of quantitative and qualitative methods can be seen [Mesgari et al. 2015]. This gap is also clearly visible when Wikipedia is repurposed for social and cultural research specifically [Rogers 2013b], where disputes and collaboration, controversies, and cultural heritage are considered.

The quantitative analyses of disputes mostly define crude metrics to assess the controversiality of an article on the whole [Laniado et al. 2011; Rad and Barbosa 2012; Suh et al. 2007; Sumi et al. 2011; Yasseri et al. 2012]. Due to the sheer size of contested articles, qualitative analyses are often limited case studies that rely on little quantifiable or comparatively grounded evidence [Fredheim et al. 2014; Massa and Scrinzi 2013]. Instead, the approach that we propose sets out to bridge this gap by leveraging Contropedia's architecture for multimethod, qualitative-quantitative analyses, where large-scale quantitative models and metrics, albeit grounded on expert judgment and manual evaluation, support interpretative investigations [Venturini and Latour 2010].

Whereas conflict and collaboration studies on Wikipedia typically compare the controversiality of articles in a particular language version, Contropedia goes beyond the identification of controversial articles and allows one to study in detail the disputes taking place during the constructing of a specific article. It combines techniques based on mining article edit histories and analyzing discussion patterns in talk pages to identify and visualize heritage-related disputes within an article and to compare these across language versions.

3.1 Quantifying Negotiations Around Wiki Links

To provide insight into the collective creation process of a Wikipedia article and explore the disputes and negotiations around its content, Contropedia relies on wiki links (i.e., links to other Wikipedia articles) as the focal points around which content and activity can be aggregated. According to Wikipedia guidelines, wiki links identify the topically most relevant concepts in an article [Wikipedia Contributors 2016] and can therefore be employed as entry points to unfold the topical loci of heritage-related disputes in an article.

A score is calculated for each wiki link according to the volume of activity around it. More precisely, the score for each wiki link is based on the number of substantial disagreeing edits to sentences containing the wiki link. Before calculating the score, however, we discard certain revisions of an article: we only wish to consider substantial edits, which actually contribute to an argument or viewpoint, and thus exclude revisions, which contain vandalism. Furthermore, as we wish to pinpoint disagreements (i.e. disputes and negotiations) as indicators of memory work, we retain only revisions that substitute or delete something from the article and discard those that only add new content. For the remaining revisions, then, we study the way in which sentences containing wiki links are affected when compared to the previous revision.

Wiki links (or elements) can be affected by an edit in the following ways: (i) *delete*, when the element is deleted from a sentence; (ii) *insert*, when it is added; (iii) *element changes*, when the element itself is modified (e.g., the way in which the link is displayed is changed); (iv) *sentence changes*, when the sentence including the element is changed but the element itself is not directly affected by the changes; and (v) *section change*, when the whole section is deleted or inserted. We consider the first four of these possibilities but exclude the fifth, as it mostly corresponds to renaming or moving sections. To reiterate, we focus on the changes to sentences containing wiki links as indicators for the activity surrounding a

wiki link. Some sentences, however, contain multiple wiki links, and to account for the lower relative importance of edits to such wiki links, we normalize the weight of an edit to such a sentence according to the number of wiki links involved. This is reflected in the formal definition of our controversiality score, which is as follows.

We define $\{R_1, \ldots, R_{r-1}, R_r, R_{r+1}, \ldots\}$ as the set of revisions of a Wikipedia article and compare each revision R_i with the previous revision R_{i-1} to identify sentences that have changed. For each such sentence S_j changed by a substantive disagreeing edit, we denote with $w(S_j)$ the total number of wiki links that appear in that sentence. The controversy score of a wiki link W_k over all revisions R_i of the page (up to a given revision R_r) is then computed as

$$c\,(W_k) = \sum_{i=1}^{r} \sum_{S_j \in R_i} \frac{1}{w(S_j)}. \tag{1}$$

In this way, the metric quantifies the amount of negotiations among edits around each wiki link in an intuitive way by counting the number of substantial disagreeing edits affecting it (normalized by number of wiki links per sentence). The metric was evaluated manually by multiple social scientists and issue experts over several examples and proved equally or more accurate than other more complex approaches, such as assigning a higher score to edits made by more experienced editors. For a more elaborate description of the metric, see Borra et al. [2015].[2]

3.2 Visual Interfaces for Data Exploration

To expose the memory work behind the current version of an article, Contropedia's interface has been designed to indicate how a topic has evolved over time and which parts were the most debated. To do so, we have adopted the interaction pattern of providing overview first and making details available on demand [Heer et al. 2012].

The interface consists of two main views. The first view, which we term the *layer view*, is an augmented version of the Wikipedia article under study and draws attention to the most debated wiki links for a given period (Figure 2). The article's temporal evolution is exposed through a timeline at the top that displays the number of edits per month. The timeline allows the user to recognize peaks in edit activity and to select a specific time range to inspect particular temporal changes. The small overview of the page, on the right side, allows users to quickly see where the most controversial elements are. The example used to illustrate this is the Wikipedia entry on feta. The layer view shows that most editing activity concerns the geographical term *Greece*, indicating disagreements around the historical origins, location, and national association of the product. In effect, rather than being an unchallenged area of culinary civilization, the article is a critical example pointing to the fact that the peculiarities of a broad spectrum of cultural heritage issues become enrolled in conflict-laden memory work.

Contropedia also provides a second, more analytical view on Wikipedia articles, which we call the *dashboard view*. Here, all controversial elements are ranked by their level of controversiality (the edit metric introduced earlier). This view also reports the elements that were intensely edited in the past but are not present in the current version anymore—and thus are not visible in the *layer view*. Such elements are shown as struck through. The dashboard view also allows one to inspect the edit network of users involved in changes to phrases containing a specific wiki link.

Additionally, in both views, it is possible to click on an element and see all related edits and discussion threads. The example in Figure 3 shows a selection of edits around the term *Greece* where various

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[2]We furthermore associate discussion threads and comments on the talk pages to wiki links. Currently, discussion activity is not considered in the metric of controversiality. See Section 4.2 for further considerations.
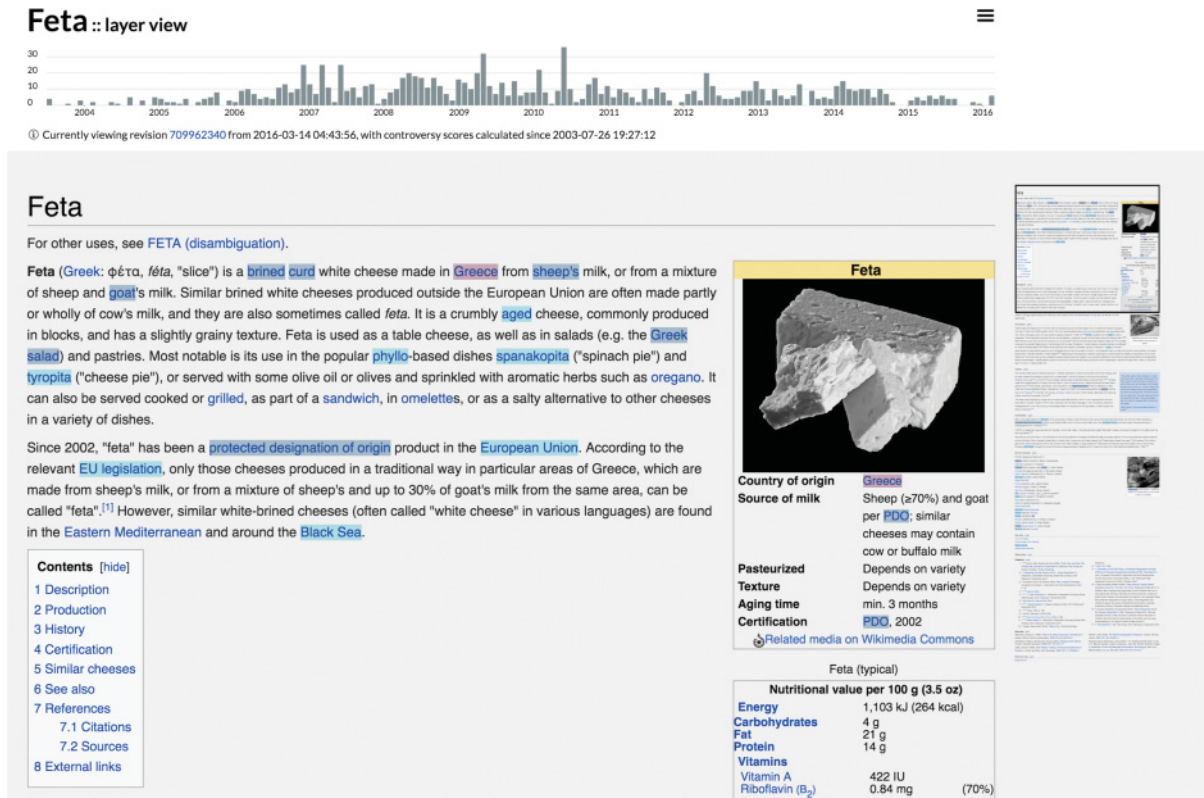
Fig. 2. Contropedia's layer view of the English Wikipedia page on feta. The more controversial an element, the redder the color. Greece is most disputed on this page. Source: Contropedia.net, March 14, 2016.

origins are suggested, such as Macedonia, Bulgaria, or Turkey. In addition to negotiations about its cultural origin, in the edit history the issue of "ownership" of the name "feta" is also discussed, as are the defining characteristics of feta, such as its ingredients (i.e., goat, sheep, and/or cow milk). The European Commission's ruling providing Greece with the "protected designation of origin" status figures prominently both as a topic of dispute as well as a key source to establish consensus in editing disputes.

3.3 Comparing Language Perspectives on Cultural Heritage

The genesis of a specific article in one language version can be used to study memory work through disentangling the various viewpoints and negotiations in place. In addition, Contropedia can also be employed for a comparative study of Wikipedia articles between language versions. In line with our earlier arguments, the encyclopedia can thus be repurposed to investigate contested perspectives on tangible and intangible cultural heritage entities across linguistic boundaries, as we showcase in the following. Previous studies have found that entries about the same topic in other languages may start with a translation from English articles but diverge significantly afterward and often demarcate different cultural visions on the same topic [Bao et al. 2012; Hecht and Gergle 2010] (see also Rogers [2013b]). Moreover, recent work has shown that linguistic or religious accordance strongly correlates with the similarity of interests across language versions [Karimi et al. 2015].
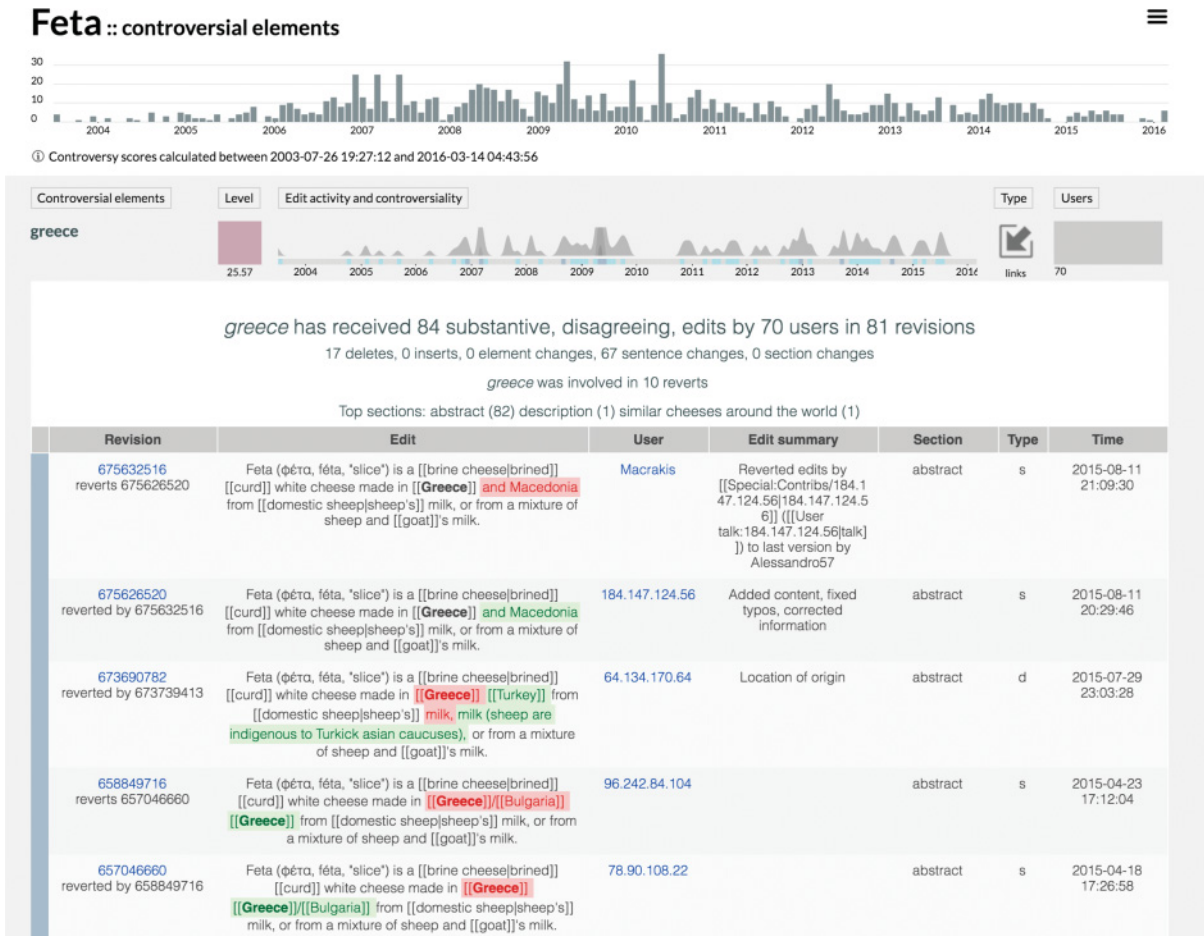
Fig. 3. Contropedia dashboard view of the English Wikipedia article on feta. It shows the most controversial element in the article as well as a partial edit table displaying a selection of substantial, disagreeing edits in sentences containing the wiki link to "Greece." Editors try to add Macedonia, Turkey, and Bulgaria as places where feta cheese is made. Source: Contropedia.net, March 14, 2016.

In Figure 4, the dashboard views of the top 10 most controversial terms in five selected language versions of the entry on "Bullfighting" are placed side by side. The figure shows the main languages spoken in the territories in which the practice of bullfighting is usually considered to form part of cultural heritage. The English language version is added as well. Written in the Web's lingua franca, it serves as an international reference. Bullfighting especially qualifies for a cross-lingual comparison for three reasons. For one, both the current practice and the history of bullfighting are highly controversial. In these debates, the very status of bullfighting becomes a veritable issue as either an element of cultural heritage and thus as a sort of art, sport, or tradition worth protecting or an archaic cruelty that needs to be abolished. These debates, then, run through different regions, languages, and cultural systems and thus reflect vernacular past and present dimensions of bullfighting as well as the vistas of other cultures on this more or less distant practice. Thus, we can investigate whether the entries in Wikipedia mirror these diverse points of view on the topic. Finally, bullfighting combines elements of
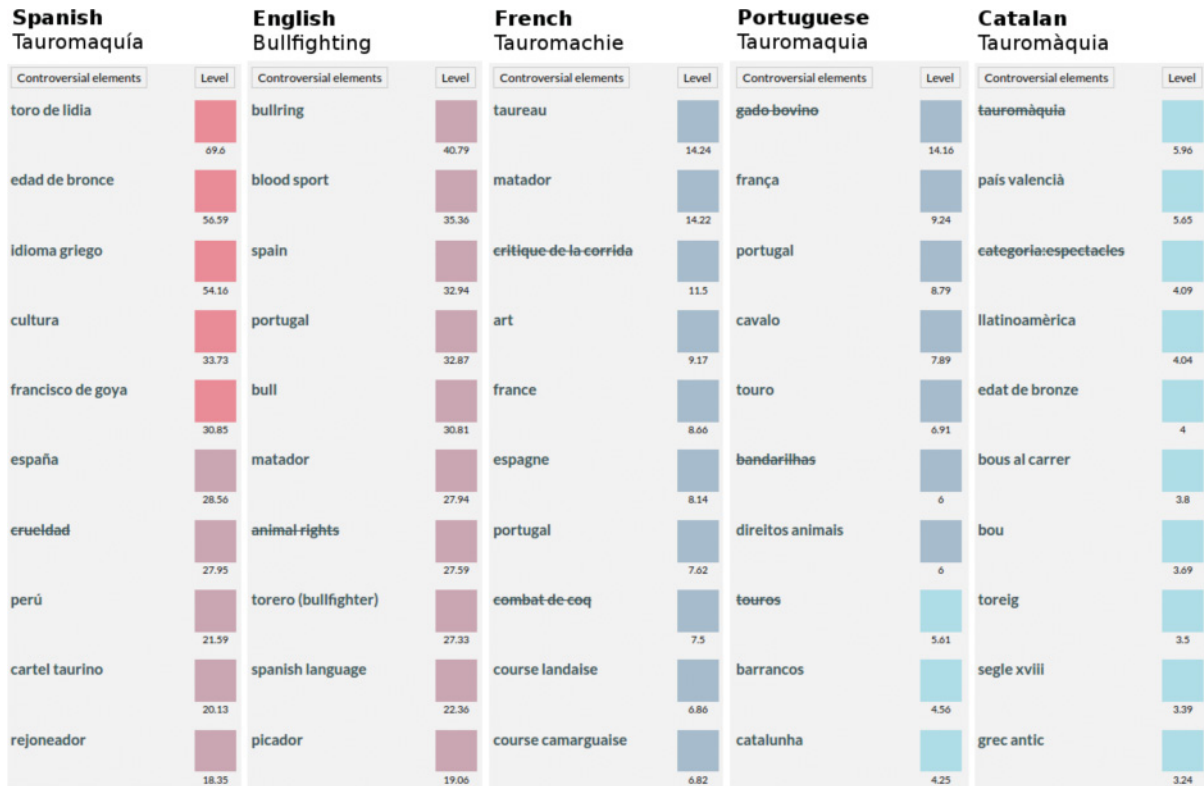
Fig. 4. Comparison of Contropedia dashboard view for entry "bullfighting" in English, Spanish, Portuguese, French, and Catalan. For each language, the 10 most controversial concepts are shown. Source: Contropedia.net, April 13, 2016.

tangible and intangible cultural heritage, as it encompasses practical performances, social meanings, traditions of training and connoisseurship, and purpose-made locations such as the arenas and a large set of specific equipment and costumes.

As is usual in Wikipedia, the topic tends to be spread over an ecology of articles in each language and across languages, such as articles about specific forms of bullfighting (e.g., "Corrida de toros," probably the most famous form of bullfighting, or "Running of the bulls") and about specific aspects of bullfighting (e.g., the "Cartel taurine," the poster used to announce a spectacle). Whereas some articles are especially concerned with its historical dimension, others foreground the criticism of bullfighting (e.g., the article "Antitauromaquia" in Spanish, or the part on "opposition à la corrida" in French). There, even the question as to where bullfighting is or has been practiced may become a problem in its own right and may open up a discourse on the various types of bullfighting that again have their own genealogy and ask for different evaluations. Articles in this ecology of topical engagement within Wikipedia hence take up similar topics, but they also roam through issues specific to certain areas and cultural contexts. Indeed, about one quarter of the articles of each Wikipedia edition's content are associated to the corresponding cultural context and do mostly not exist in other languages [Miquel-Ribé and Laniado 2016]. For developing this cross-language example, we chose to focus on the article about the general concept of bullfighting and compare cultural representations of the same entry in different Wikipedia editions. Therefore, the objective of this case study is to describe and qualify the specific positions and concerns of five language entries in the case example of bullfighting.

Although language versions often start with a translation from the English entry, the versions of the bullfighting entry are all written from scratch, providing us with an opportunity to say something about how these entries have developed a local focus point starting from a blank slate. This, for example, becomes apparent in the structure of the table of contents, the use of figures, and the specific issues and concerns in language entries. Furthermore, the majority of languages in view are spoken in different areas and may thus also bring together various local perspectives in one article version.

The Spanish entry is the most comprehensive in terms of describing bullfighting as (national) culture. The entry pays attention to its history, different styles, components of the tradition, most famous festivities, venues, fairs, and awards. The main article addresses some critical aspects in one paragraph but displaces a more thorough criticism by linking to a dedicated article ("Antitauromaquia"). Overall, this suggests that the consensus in this entry is that bullfighting is a protectable kind of cultural heritage. However, looking at the most controversial terms and phrases in the Contropedia dashboard, we observe that there are issues with regard to the prominence and positioning of criticism in the entry. This is exemplified by the term *cruelty*, which is a crossed-out element, indicating that a link to the concept was removed from the article. Yet the most controversial concept in the Spanish entry has to do with the basic definition of bullfighting itself, where the verb "fighting" ("lidiar") has been repeatedly substituted by other verbs, such as "killing," "murdering," "wounding," or "torturing," which frame it as an act of barbarity rather than a matter of fact. A reference to the official definition from the Real Academia Española ("el arte de lidiar toros," i.e. "the art of fighting the bull") was added to solve the dispute. Other negotiations in the Spanish article concern the historical and cultural roots of bullfighting and the role of intellectuals and artists such as the painter Francisco de Goya. Interestingly, by way of discussing the cultural status of bullfighting, culture itself becomes a disputed concept along a controversy of what should actually belong to a national culture and what should count as the relevant national cultures in this case. Hence, questions about local traditions of bullfighting resonate with a far-reaching contention about national singularity and joint cultural areas.

The English version can be viewed as representing an "international reference" to bullfighting compared to the other language entries representing regions where some form of bullfighting is, or was, practiced. The entry is distinct in its apparent consensus on a critical approach to bullfighting, exemplified by being the only one that categorizes the article under animal welfare, blood sports, and related categories in addition to the more descriptive category of bullfighting. In terms of imagery, the English version is unique in showing a close-up image of a dying bull. Under "popularity," the English version discusses a range of criticisms to bullfighting at length, ranging from animal welfare via issues of funding, politics, and religion to media prohibition, declarations as cultural patrimony, and bans. Throughout the article, it is recognized that there are deeply diverging viewpoints on bullfighting, ranging from bullfighting as a key cultural practice and a form of art to bullfighting as a blood sport and bullfighting as a sadistic tradition of torturing and killing. Looking at the most controversial terms and phrases, the top-most element in the dashboard view of the English entry is "bullring" due to edits about the places where bullrings can be found and some controversies associated to their cultural significance as current or former places of varying sorts of bullfighting. Similar controversies as in the Spanish version appear prominently in the English version, too, especially those concerning the fundamental description of the practice that comes with an elementary evaluation. This is exemplified by the term *blood sport* in the English language version, a concept used to define bullfighting in the introduction of the article.

The French version is a much shorter entry compared to the previous two (the article "Corrida" seems to be more significant than "Tauromachie"). The main focus of the article is on establishing that there are significant differences in the many local styles of bullfighting. The initial abstract of the text is entirely devoted to explaining that bullfighting cannot be reduced to a synonym of the

Spanish *corrida*, as it does not represent the richness and diversity of the many different codified practices of bullfighting. From the structure of the table of contents, it can be read that the main difference the entry makes is between bullfighting "with killing" and "without killing," where the latter is often considered a sport. The article has a stronger focus on the second sort of traditions of which it describes many examples from different regions of France, Spain, and Latin America. Looking at the most controversial terms and phrases in the dashboard, one of the key controversial terms is *art*, used in the definition of bullfighting ("the art of facing the bull") and replaced by various users with other words such as *practice*, *way*, or *technique*. We also find references to "Course landaise" and "Course camarguaise," which are bullfighting spectacles typical of two French regions, with a controversy about whether they should be defined as "sports" or "regional sports." It is also noticeable that a link to an entry devoted to "Criticism of bullfighting" was removed from the French article so that the current version does not feature any critique.

The Portuguese entry seems to be most affected by diverging viewpoints, as the quality of the entry has been disputed since November 2009 (which is indicated by a prominent banner at the top of the entry, denoting that it was marked for revision due to inconsistencies or questionable reliability). The talk page shows that there is a significant disagreement between those who defend bullfighting as an aspect of heritage and those who focus more on animal rights, although they also agree that is represents a cultural tradition. The article is the only one among the selected entries that has a section specifically dedicated to cultural heritage, in which the countries and regions that consider bullfighting as such are addressed. An extensive part on criticism is also included in the main article. In terms of the most controversial terms in the dashboard, we can observe a connate debate on "animal rights" and a controversy around the term *Portugal* concerning the prohibitions of bullfighting in different moments of the history of the country, namely in 1836 and 1928, until a change in the law in 2002 allowed bullfighting in specific venues where it has been declared intangible cultural heritage, such as the village of Barrancos.

The Catalan version is relatively short compared to the other variances, but it nonetheless presents a distinct local perspective stressing the cultural independence of Catalonia from Spain in this matter. This is, for example, illustrated by the choice of figures. In addition to opting for primarily local images (from bullfights in Barcelona), a striking example is the map of Spain depicting where (and to what extent) *corrida* is practiced in green and where it is banned in red (i.e., Catalonia), creating a stark visual contrast between Catalonia and the rest of Spain (Figure 5). In contrast, a similar map is used in the Spanish, English, and Portuguese versions with different colors and coding (Figure 6). The large majority of Spain is red, indicating that bullfighting is legal. Catalonia is purple, indicating that "bullfighting [is] banned, but other spectacles involving fighting cattle [are] protected by law." The much more distinctive colors blue and green are respectively reserved for the Canary Islands, where any kind of bullfighting is banned, and for some of the Balearic Islands, where bullfighting is legal but traditionally not practiced. Indeed, Spanish-style bullfighting is banned in Catalonia, but other forms of bullfighting are still allowed. The most contested terms in the Catalan version show that many negotiations concern the "País Valencià" ("Valencian country," where Catalan is spoken) and the practice of "bous al carrer" ("bulls in the street"), a traditional spectacle typical of that region and of southern Catalonia ("Terres del Ebre"), where it is still tolerated by Catalan law. From 2005 to 2008, the abstract of the Catalan article presented "bous al carrer" as "the most elaborated expression" of bullfighting, which was then changed to "a variant" of bullfighting. The introductory paragraph thus marks a critical difference between this tradition and the most known practice of *corrida*, in which a matador kills the animal, "considered by many as an element of identity in Spain, Mexico, Bayonne and the Rhône (Occitan), while considered by many others as an act of cruelty." It is interesting to notice that the Catalan article is the only one in which such critical voice is mentioned in the abstract
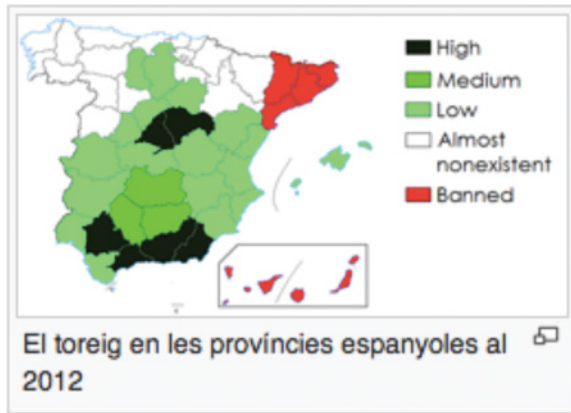
Fig. 5. Map of bullfighting in Spain depicted in the Catalan entry. Source: https://commons.wikimedia.org/wiki/File: Bullfighting_in_Spain_by_province.png; author: Zayuk.

Fig. 6. Map of bullfighting in Spain depicted in the Spanish, English, and Portuguese version. Source: https://commons. wikimedia.org/wiki/File:Tauromaquia_en_España.PNG;   author: Fobos92.

itself. Indeed, ethical concerns for animal rights seem to be entangled with national identity issues in Catalonia, where this practice, banned in 2010 after a popular legislative initiative, is seen by many as strongly associated to Spanish national identity as opposed to Catalan identity.

4. A CONCEPTUAL, TECHNICAL, AND PRACTICAL OUTLOOK

The analysis architecture of Contropedia with its theoretical underpinnings can form part of a more comprehensive infrastructure for engaging with digital cultural heritage on different yet related dimensions. In what follows, these dimensions are drafted along a conceptual, a technological, and a practical outlook. Taken together, they comprise the appraisal of productive friction and media affordances, the construction of an extended framework, and the promotion of outreach initiatives.

4.1 Conceptual Outlook: Appraising Productive Friction and Media Affordances

Returning to the observation at the onset of this article, Wikipedia is both a material and an intellectual manifestation of cultural heritage as well as a gateway opening up knowledge about cultural heritage. Its contentious formation challenges, on a conceptual level, any attempt to treat cultural heritage as a taken-for-granted stock of tangible and intangible items or ideas. Instead, the Contro-

pedia tool discussed here offers to materially investigate into a larger shift in modern societies and their ways of knowing. Thus, whereas information was previously provided by authoritative sources, there is currently a multiplication of expert types and forms of potentially discordant expertise that are increasingly available to the public [Latour 2005].

Yet instead of worrying about such disagreements, they can be embraced as an essential part of collective existence whose dynamics can be positively channeled (or at least the most destructive outcomes can be avoided) by helping people to deploy the complexity of controversies [Callon et al. 2009; Marres 2015; Venturini 2010, 2012]. Following Lowenhaupt-Tsing [2005], the contentious exchanges can be viewed as "productive friction" (p. 3). Seen this way, especially the comparison across different languages and, what often comes with that, cultural boundaries supports to appreciate the "creative qualities of interconnection across differences" (p. 4) that lie at the heart of knowledge production in Wikipedia but can also speak to the engagement with cultural heritage at large.

In this respect, the effort to equip people for acknowledging, understanding, and managing debates seems particularly relevant in the computational study of memory work around cultural heritage. Yet handling negotiations in memory work in a productive way demands tools—tools to render disputes and controversies more "readable" to help citizens navigate through their disagreements and to find unity beyond them [Cassin 2001; Stengers 2010]. Developing such tools is becoming feasible with the growing traceability of collective discussions in digital media, notably in Wikipedia [Rogers 2013a].

To this end, an interdisciplinary conceptual framework must be devised so to account for the interplay of digital cultural heritage and the affordances of digitally networked media technologies [Bowker 2009; Van House and Churchill 2008; Ernst 2013; Parikka 2012, Weltevrede and Borra 2016]. Hence, to acknowledge the technicity of cultural heritage at large, Wikipedia cannot be taken to be a mere aid or venue to materialize and make accessible legacies of artifacts and systems of value and meaning. Instead, Wikipedia presents one pivot for constituting cultural memory and thus the semantic base of cultural heritage *sui generis* as it prefigures and generates the procedures through which a particular type of memory work can be done. As such, Wikipedia forms part of a larger ecology of knowledge resources found in other wikis and Web projects as well as of social platforms like Facebook, YouTube, or Twitter [van Dijck 2013]. Together, they dominate social interaction and connective communication within and across national, cultural, and linguistic borders and ask for appropriate tools to gauge their potential for research and engagement in digital cultural heritage.

4.2 Technical Outlook: Constructing an Extended Framework for Digital Cultural Heritage Studies

The Contropedia architecture introduces a computationally efficient way to identify the focal points of negotiations and dispute around cultural heritage in Wikipedia articles. Further improvements can be made, such as those accounting for the social and temporal dynamics in the complementary edit and discussion spaces of each article, and those that allow for an analysis at different levels of granularity, ranging from sets of related articles to individual sections and elements within an article.

Controversiality metrics of Contropedia might be extended and refined to include dynamic knowledge more broadly through iterative manual evaluation considering a variety of elements such as specific kinds of edits; editor seniority [Yasseri et al. 2012]; discussion thread depth [Kaltenbrunner and Laniado 2012]; special interaction patterns such as mutual reply chains [Laniado et al. 2011]; and other activities such as protecting or flagging a page, or banning a user. Such measures and the corresponding visualizations would allow for combining mathematical modeling of user behavior with a more qualitative observation of these dynamics by experts. This could improve the analysis of interactions between different points of view, consensus reaching, and the presence of opposed camps of users.

In line with digital methods' adagium to "follow the medium" [Rogers 2013a], the Web content analysis being put forward here makes use of key platform-specific features and functions on Wikipedia

(see also Weltevrede and Borra [2016]). Although Contropedia has shown that wiki links are central to detect loci of dispute, its approach could be extended by considering other units of content in an article around which disputes can appear, such as images, external references, and templates. So Wikipedians use different templates to indicate whether a particular point of view is pushed of if images generate a lot of discussion [Rogers 2013a]. External references, furthermore, are commonly used to "settle" disputes and enforce consensus [Tkacz 2015]. Charting and qualifying these external references would allow for providing context to resolve dispute in an article and facilitate the study of which types of links (e.g., academic or news) are typically used to solve conflict in a particular language version of Wikipedia and which ones are more often contested. Systematic retrieval of all external references from a set of articles, and their interconnections, would allow one to contextualize the debate in the articles in the larger debate in society, beyond Wikipedia, and provide an indicator for assessing the maturity of articles as well as an important measure for how facts, truths, and accounts are established in different language versions and how they compare to each other. Beyond focusing on special elements as mentioned earlier, one might also consider the history of individual words to show which words were added and deleted more frequently, as envisioned in Flöck et al. [2015].

Talk pages—parallel spaces for explicit coordination among editors about an article—are also a fundamental place for negotiations and consensus reaching. The Wikipedia interface offers no explicit association between discussion threads on these pages and edit activity, and the two are mostly treated separately in current research, although they are strongly interconnected in the work practice. A first systematic comparison of edit and discussion activity streams has shown that they have only a limited temporal overlap [Kaltenbrunner and Laniado 2012], indicating that considering both is essential for getting a full comprehension of collaborative content production processes. Discussions in talk pages are currently only included in the detailed view of Contropedia. The current association of comments from talk pages to wiki links is based on a combination of string matching (when a wiki link is mentioned in a comment) and mining of co-occurrent activity (when the same users edit in the same time window the talk page and a sentence in the article including a wiki link). Full integration of metrics based on discussion and on editing activity is a clear path for future improvements.

In terms of visualization models (how data are displayed) and interaction patterns (how users can manipulate the visualizations), the Contropedia architecture currently presents limits in its upscaling. Contropedia was designed to focus on single articles in one language. The comparison among different language versions and the exploration of groups of pages require a design that adopts a wider approach, meant to identify coherent visual models able to represent multiple variables at different scale levels, from the macro to the micro view on the compared information. To untangle such complexity, a multiple views approach [Mauri et al. 2013] could be adopted, providing multiple perspectives on the analysis results. This kind of solution would require the identification of the main elements (e.g., articles, users, controversial elements, edits) and the relation among them, identifying the best visual solution for each relationship. Other possible design solutions, which could be used as inspiration for a new interface, include the cross-language comparison at the article level of Omnipedia [Bao et al. 2012], the side-by-side comparison of two language versions of an article in Manypedia [Massa and Scrinzi 2013], and the comparison of controversiality levels across languages in InfoCrystal [Yasseri et al. 2014].

4.3 Practical Outlook: Fostering Engagement with Digital Cultural Heritage

To form a larger digital cultural heritage infrastructure, Contropedia's analysis architecture can be embedded in pedagogical and broadcasting activities that reach out to educational contexts such as schools, universities, and museums, as well as to the general public.

Within the wider field of an active engagement with cultural heritage, historical knowledge usually gets communicated to the general public in the form of apparently neutral discourses providing single versions of facts. Given that many exhibitions, documentaries, or publications about cultural heritage seek to explain what happened and how it happened, in the most accessible and sometimes entertaining way, only few of them show the debates and negotiations behind a specific narrative. In the same way, the general public does not expect cultural or educational media to provide multiple versions of the same story. On that basis, controversies seem to belong only to specialists. It is in this regard that digitally mediated memory work around tangible and intangible heritage, like we find on Wikipedia, challenges the authority of traditional heritage agencies and formats to convey cultural heritage. This is especially visible when it comes to themes of which the opinions and interpretations that enter the public debate seem very sensitive and controversial.

From this backdrop, Contropedia can form part of a wider infrastructure for digital cultural heritage engagement that helps to challenge unique points of view in favor of a comprehensive and inclusive understanding of cultural heritage in both education and communication. To this end, using the interface and analysis provided by the tool can support history educators to encourage pupils and students to think critically about issues of memory, historical knowledge, and heritage traditions and to contribute their points of view and experiences to an ongoing cultural debate. This ties in with some longer-standing approaches to learning that foster critical thinking, encouraging student motivation and engagement, and cultivate active, independent, and creative learners [Council of Europe 1998; Brown and Hay-Edie 2013]. Through this, it can become visible to which extent cultural heritage is a negotiation stemming from scholarly historical insights and theories as well as collective commemoration.

More broadly, it can be argued that public communication of cultural heritage should outgrow the limits of national identities and draw people toward each other in a plural and multicultural society with a shared cultural heritage—including the heritage of war and conflict. In this respect, Contropedia shows how different accounts of a particular cultural heritage are constructed and contextualized within systems of value and worth. By allowing the user to navigate through diverse representations and controversies, backward and forward, from one to the other, Contropedia sheds light on the diversity of versions of cultural heritage and gives the opportunity to compare them. Through this, it can put the accounts into context to turn disagreements into constructive and educative materials.

5. CONCLUSION

In this article, we have argued that Wikipedia functions both as a digital gateway to the active engagement with cultural heritage as well as a key contemporary digital heritage site in itself. Building on the double nature of the project, we propose the open source analysis architecture Contropedia to facilitate the study of collaboratively generated participation around cultural heritage. With this, we recognize the position of Wikipedia as an increasingly canonical platform for the documentation and construction of knowledge about material and immaterial cultural heritage that goes beyond other forms of social media in terms of structure, comprehensiveness, and transcultural scope.

Building on that, we have discussed the outlook on an extensive conceptually based, technologically advanced, and practically enrolled infrastructure for advancing the understanding of and engagement with cultural heritage. Regarding the recent academic discourse about the implications of computational techniques for cultural heritage analysis, conversation, and propagation, this emerging infrastructure can help to appreciate the changing ideas of what cultural heritage actually is or should be in contemporary societies [Giaccardi 2012; Katz et al. 2011].

Theoretically, we propose the notion of "memory work" to appreciate how present concerns play out in negotiations and disagreements about the heritage of the past across different cultures and

linguistic boundaries. Grounded on this idea, Contropedia opens up the creation of encyclopedic articles on historical objects, ideas, events, or persons where volunteer editors contribute and discuss personal understandings, historical insights, and scientific references to construct knowledge around cultural heritage. Technologically, Contropedia offers an outlook in terms of tool development. The analysis architecture groups edits and discussions topically and calculates the loci of negotiations about cultural heritage. Although Wikipedia data is abundant and publicly available, Wikipedia's interface is not primarily designed to facilitate such analysis. Contropedia presents Wikipedia edit and discussion data in analytical interfaces that facilitate the examination of articulated perspectives on cultural heritage. Practically, Contropedia has the potential to become an analytically insightful resource to cultural heritage studies and outreach initiatives. It contributes to ongoing efforts in supporting and managing the use of facilities and applications in the digital heritage sector. Moreover, it can be employed as a powerful tool for public education, providing insights in both the frictions around the formation of perspectives on cultural heritage and the production of knowledge in a key contemporary peer-produced digital heritage endeavor.

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